Advanced Information Systems Technology

Tradespace Analysis Tool for Designing Earth Science Distributed Missions

Completed Technology Project (2015 - 2017)

Project Introduction

The ESTO 2030 Science Vision envisions the future of Earth Science to be characterized by 'many more distributed observations,' and 'formation-flying [missions that] will have the ability to reconfigure on the fly and constellations of complementary satellites with different capabilities will work together autonomously.' All these concepts refer to 'Distributed Spacecraft Missions (DSMs)', i.e., missions that involve multiple spacecraft to achieve one or more common goals, and more particularly to 'constellations' or 'formations', i.e., missions designed as distributed missions with specific orbits from inception (in contrast to virtual or ad-hoc DSMs being formed after launch). DSMs include multiple configurations such as homogenous and heterogeneous constellations, formation flying clusters and fractionated spacecraft. They are gaining momentum in all science domains, because of their ability to optimize the return on investment in terms of science benefits, aided by the increasing prevalence of small satellites. In Earth science, DSMs have the unique ability to increase observation sampling in spatial, spectral and temporal dimensions simultaneously. Many future missions have been studying the possibility of using constellations to satisfy their science goals. However, since DSM architectures are defined by monolithic architecture variables and variables associated with the distributed framework, designing an optimal DSM requires handling a very large number of variables, which increases further in heterogeneous cases. Additionally, DSMs are expected to increase mission flexibility, scalability, evolvability and robustness and to minimize cost risks associated with launch and operations. As a result, DSM design is a complex problem with many design variables and multiple conflicting objectives. There are very few open-access tools available to explore the tradespace of variables, minimize cost and maximize performance for pre-defined science goals, and therefore select the most optimal design. Over the last year, our team developed a prototype tool using the MATLAB engine and interfacing with AGI's Systems Tool Kit. The prototype tool is capable of generating hundreds of DSM architectures using a few pre-defined design variables, e.g., number of spacecraft, number of orbital planes, altitudes, swath widths, etc. and sizing the architectures' performance using the limited metrics available in the off-the-shelf components. Currently, only Walker constellations are being considered. We have found off-the-shelf components do not support the necessary functionality to explore and optimize DSMs based on specific science objectives and architecture requirements. In the proposed work, the tool will be generalized to consider a larger number of parameters and metrics and different types of constellations, to enable analysis and design of architectures in terms of pre-defined science, cost, and risk metrics. The product will leverage existing modeling and analysis capabilities available in the General Mission Analysis Tool (GMAT), developed at NASA Goddard. GMAT is an open source, trajectory optimization and design system, designed to model and optimize spacecraft trajectories in flight regimes ranging from low Earth orbit to lunar applications, interplanetary trajectories, and other deep space missions. The tool will include a user-friendly interface that will enable Earth

Image Not Available

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Center / Facility:

NASA Headquarters (HQ)

Responsible Program:

Advanced Information Systems Technology

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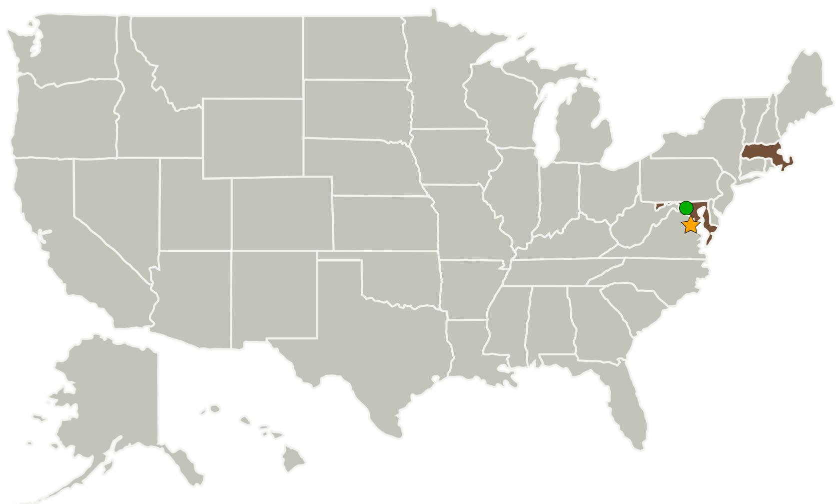
Scientists to easily perform tradespace analyses and to interface with this tool when performing trades on planned instruments and when conducting Observing System Simulation Experiments (OSSEs) for mission design. The software developed under this proposal will enable: (1) better science through distributed missions, (2) better communication between mission designers and scientists, (3) more rapid trade studies, (4) better understanding of the trade space as it relates to science return. The final tool will be offered open source to the Earth Science community.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★NASA Headquarters(HQ)	Lead Organization	NASA Center	Washington, District of Columbia
●Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations	
Maryland	Massachusetts

Project Management

Program Director:

Pamela S Millar

Program Manager:

Jacqueline J Le Moigne

Principal Investigator:

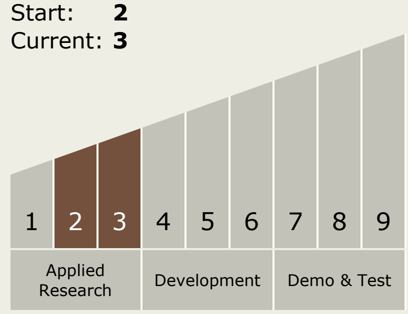
Jacqueline J Le Moigne

Co-Investigators:

Michael A Johnson
Philip Dabney
Steven P Hughes
Joel J Parker
Sreeja Nag
Oliver L De Weck

Technology Maturity (TRL)

Start: **2**
Current: **3**



Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  └ TX11.4 Information Processing

Continued on following page.

Technology Areas *(cont.)*

└ TX11.4.2 Intelligent Data Understanding

Target Destination

Earth